

Magnetic properties of high B_s CoNiFeB soft magnetic thin films prepared by electroless deposition

T.Yokoshima, M.Sobue, D.Kaneko, T. Osaka,
S.Takefusa^{*}), A.Tanaka^{*})

*Department of Applied Chemistry, School of Science and Engineering; Kagami Memorial Laboratory for Materials Science and Technology, Waseda University
3-4-1, Okubo, Shinjuku-Ku, Tokyo, 169-8555, Japan
^{*}Fujitsu Laboratory Ltd.*

*10-1, Morinosato-Wakamiya, Atsugi, Kanagawa,
243-0197 Japan.*

Recently, the areal recording density has been increasing dramatically in magnetic recording systems, especially in the hard disk drive (HDD). The development of a magnetic recording head with better recording performances and smaller dimensions is one of the key requirements for realizing a high-density magnetic recording device. Soft magnetic thin films with high saturation magnetic flux density (B_s) are required to magnetize high coercivity medium for high-density magnetic recording. We also developed electrodeposited CoNiFe soft magnetic thin films with the very high B_s value of 2.0T [1]. On the other hand, for the fabrication of fine head cores, electroless deposition has advantages of fabricating smaller and finer head cores compared with the electrodeposition method which is the conventional technique of fabricating head cores [2]. Therefore, we also investigated electroless CoNiFeB soft magnetic thin films; however, those films possess the B_s value of only 1.5-1.7 T because of the low Fe content of 9 at% [3]. In this study, we attempted to increase the B_s value of electroless CoNiFe thin films by increasing the Fe content.

All CoNiFeB thin films were prepared by means of electroless deposition. They were deposited on the sputtered Cu/Cr/glass, and the film thickness was controlled to 1 μ m. The bath composition was based on the CoNiFeB bath [3] with an increased FeSO₄ content. Magnetic properties were measured by using a vibrating sample magnetometer with an earth magnetic field compensation circuit (VSM). The film composition was analyzed by X-ray fluorescence (XRF) and inductively coupled argon plasma atomic emission spectroscopy (ICP). The crystal structure was examined by X-ray diffraction (XRD, Fe-K α).

Firstly, an attempt was made to increase the B_s value of electroless CoNiFeB thin films by increasing the Fe content. Upon increasing the Fe concentration in the basic plating bath, the deposition rate rapidly decreased and the Fe content of the CoNiFeB thin film increased up to 30at%. However, H_c value increased rapidly from 2 Oe to 40 Oe. The H_c value was decreased by optimizing the bath compositions such as complexing agent and reducing agent, however, the CoNiFeB films with H_c lower than 10 Oe could not be obtained.

Secondly, to improve the H_c value, the effect of agitation speed on the deposition behavior and magnetic properties of electroless CoNiFeB films was investigated. The deposition rate showed a maximum in the range of 40 and 80 cpm (cycles per minute) of the agitation speed. The film composition depended on agitation speed, and the Fe content decreased up to 60 cpm, and it increased when the agitation speed was made greater than 60 cpm. Figure 1 shows variations of B_s and H_c values of the electroless CoNiFeB thin film with agitation speed. It is seen that the B_s value remained at the high value of 1.8-

2.0 T, which was essentially independent of agitation speed. On the other hand, the H_c value greatly depended on agitation speed, and the value in the range of agitation speed from 40 and 60 cpm was less than 3 Oe. One suitable film has the composition of Co₆₃Ni₁₃Fe₂₃B₁ with B_s = 1.8-1.9 T and H_c < 3 Oe.

Finally, to clarify the reason why the new CoNiFeB thin film has a low H_c value, the microstructure of the film was analyzed by XRD. Figure 2 shows the XRD patterns of CoNiFeB thin films with and without agitation. The XRD patterns show that grain size decreased with agitation. Such small grain sizes must have induced the low H_c values of these films.

From these results, we confirmed that soft magnetic properties such as H_c greatly depend on agitation effect. We thus successfully prepared electroless CoNiFeB soft magnetic thin films with high B_s by optimizing agitation conditions.

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References

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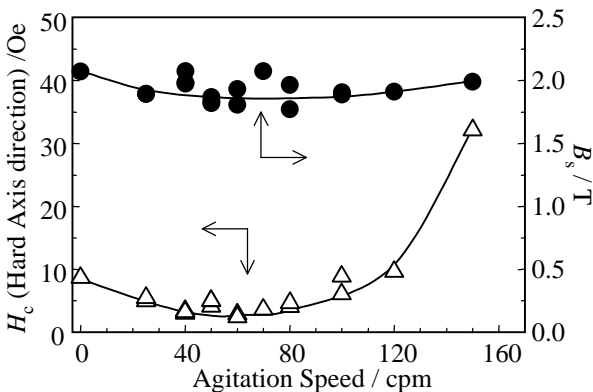


Fig.1 Relation between agitation speed and magnetic properties of electroless CoNiFeB thin films with high B_s value. Filled circles and open triangles show B_s values and H_c values, respectively.

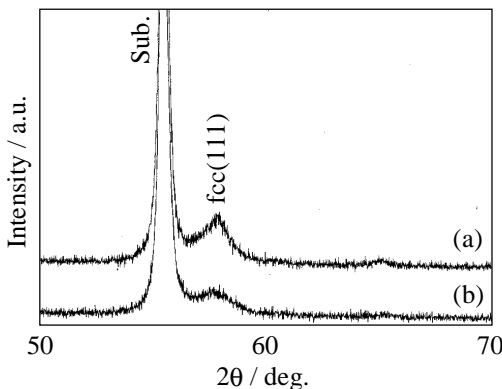


Fig.2 XRD patterns of electroless CoNiFeB thin films; (a) without agitation, (b) with agitation (40 cpm).